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warping of the surface. The streams again began to adjust themselves to their new conditions, a work in which they are still engaged.

Hayes has made out the following changes which the streams have gone through in reaching their present courses. First, they moved westward to the interior sea as antecedent streams during the first cycle. Then they were diverted southward to consequent courses, and at last flowed westward as subsequent streams.

The way in which peneplains are correlated forms an interesting section of the paper. The types of stream basins as found in the region are vividly described. The maps, of which there are five, repay careful study.

F. H. H. C.

Geology of Minnesota, Final Report, Vol. IV. By N. H. WINCHELL, U. S. GRANT, WARREN UPHAM, and H. V. WINCHELL. Quarto, pp. i-xx, 1-630, with 31 geological maps, 48 photographic plates, and 114 figures. St. Paul, 1899.

This volume, which completes the areal geology of the state, follows its predecessors in the geographic arrangement of the subject-matter. The area covered embraces the northern third of the state, and includes some thirty counties and districts. The bed rock of the region, with the exception of scattered patches of Cretaceous, is almost universally crystalline in character, and is referred to the Archean and Taconic. The thickness of the drift is very great throughout most of the region considered, several counties in the northwestern part of the state presenting no outcrops whatever of the bed rock.

The crystalline rocks in this largely new field have naturally received much attention, resulting in the accumulation of a considerable mass of new facts relating to the Archean and Taconic, especially the former. The interpretations based upon these facts differ considerably from the commonly accepted views as to the character and divisions of the ancient crystalline rocks, and especially as to the assumed representative of the original crust of the earth.

It is to be regretted that the first presentation of a new classification should be somewhat lacking in clearness, but nowhere in the volume is there a satisfactory statement of the divisions into which the various clastic and igneous rocks of the state have been separated, nor of the equivalents in the ordinary classifications. As nearly as

may be judged from the report, the classification of the pre-Silurian rocks adopted by the survey is as follows:

Cambrian (St. Croix, "Potsdam")		
(Upper Cambrian)		
Taconic (Lower Cambrian)	{ Keweenawan	{ Potsdam (clastic) and Manitou (igneous)
		{ Cabotian (igneous)
	{ Animikie	
Archean	{ Upper Kewatin	
	{ Lower Kewatin	

I. ARCHEAN

1. *Lower Kewatin*.—The rock of the Lower Kewatin is in general designated by the survey as greenstone, and is composed of two divisions: (1) A lower massive igneous greenstone, assumed to represent the original crust of the earth, and (2) an upper series, partly fragmental and partly chemical, including beds of basic tuff, of agglomerate, and of conglomerate, the jaspilytes and iron ores of the Vermillion range, and vast masses of quartz-porphyry. Both the jaspilytes and the porphyry are tentatively held to be the result of chemical precipitation in the Archean ocean, the apparent dikes of the porphyry in the Upper Kewatin being considered as infolded masses, or as intrusions brought about by plasticity due to the subsequent application of heat and pressure.

2. *Upper Kewatin*.—The Upper Kewatin consists of a basal (Ogishke) conglomerate, overlaid by a series of graywackes, argillytes, and a single jaspilyte. The fragmental members are characterized by the presence in greater or less amounts of greenish material supposed to have been largely derived from the waste of the lower Kewatin, and from the Archean volcanoes. The whole series is involved with the Lower Kewatin in vertical isoclinal folds.

All the members of the Kewatin, both Lower and Upper, have been locally strongly metamorphosed, giving rise to clastic gneisses, schists, etc., where the action was simply one of recrystallization, and

to granites, syenites, diabase, gabbro, etc., where complete hydrothermal fusion took place.

II. TACONIC

This is considered as the time equivalent of the Lower Cambrian, and is separated from the Upper Kewatin by a marked unconformity. It is separated into two divisions, the Animikie and the Keweenawan.

1. *Animikie*.—The Animikie consists of a series of graywackes, slates, and quartzites, and the Mesabi iron ore series. The beds vary in dip from nearly horizontal to 45° . There are no known contemporary lava flows, but the rocks are characterized by the presence of numerous sills and dikes of diabase intruded during the interval separating the Animikie from the overlying clastics (Potsdam).

2. *Keweenawan*.—The clastic part of the Keweenawan is considered as Potsdam and is separated from the Animikie by a distinct unconformity. It begins with a basal conglomerate, usually red in color and of varying coarseness, known as the Puckwunge conglomerate, and is followed by quartzites and sandstones interbedded with lava flows of great volume and extent. The sedimentary beds became progressively thicker as the igneous activities waned, finally terminating in the white and siliceous sandstone of the overlying formation (Upper Cambrian). The dip is even more gentle than in the Animikie.

The eruptives of the Keweenawan are divided into two divisions, the Cabotian and the Manitou.

(a) *Cabotian*.—The Cabotian includes the great masses of gabbro, anorthosite, diabase, etc., which in time of origin immediately antedate the Puckwunge conglomerate. In consequence of the great extrusion of igneous material, designated as the "great gabbro revolution," large areas of the Animikie were covered with heated lavas, resulting in the fusion of considerable portions of the former. Contemporary with this flow there were also important intrusions of gabbro as sills and dikes in the unfused portions of the series.

(b) *Manitou*.—The Manitou series is made up of a great number of surface flows, showing amygdaloidal and brecciated partings, and alternating with beds of sandstone in the upper portion. The first of the series appear as contemporaneous beds associated with the basal, or Puckwunge conglomerate, but the greater part of the eruptives are of a distinctly later date.

III. CAMBRIAN

The eruptives of the Manitou series gradually cease and give place to whiter and more siliceous sandstones, which in turn give way without any general break to the magnesian and argillaceous limestones of the Upper Cambrian. These Upper Cambrian rocks are of comparatively slight extent and importance in the area covered by the report.

Igneous rocks.—The igneous rocks, both acid and basic, of the Archean and Taconic are regarded as originating from the hydrothermal fusion of the older rocks, mostly from the clastics. The intermediate stages may often be seen.

The igneous rocks are of three classes—granites, diabases, and quartz-porphyrries. The granites are of three relative ages, two being Archean and the third Taconic. They are referred to the fused portions of a still earlier acid clastic. The diabases are also of three relative dates, in this case one being in the Archean and two in the Taconic. They are believed to have been derived from the lowest greenstones, or to occur as apophyses of the gabbro, itself a secondary condition of the greenstone. The quartz-porphyry dikes are again of three periods, one each in the Lower and Upper Kewatin, and one cutting portions of the Taconic. They are supposed to have been derived from the great quartz-porphyry mass of the Lower Kewatin, or from some later clastic.

Glacial Geology.—Besides the mass of observations relating to the crystalline rocks, there are a considerable number relating to the glacial geology of the northern portion of the state, but these observations are not systematically discussed with reference to the great problems of glacial geology.

The thirty or more maps included in the report give, in addition to the geology and ordinary topographic features, approximate contours for every fifty feet, which adds greatly to their usefulness and value. The maps are pleasingly colored and neatly executed. The volume is profusely illustrated by photographic reproductions and line cuts. The former, especially, are numerous, and though not always what might be desired in the point of clearness and appropriateness, add materially to the attractiveness and value of the report.

As one reads the report he cannot but be impressed by the great number of observations made and the mass of facts accumulated, but the disconnected and unsystematic manner of presentation, which necessarily follows from the geographical treatment adhered to

throughout the volume, detracts greatly from the value they would otherwise possess. Too much is left to be inferred, and there is always a strong liability of error in the putting together of scattered observations from various localities which the reader is obliged to do for himself in order to obtain an intelligent understanding of the questions treated.

It is proposed in the next volume of the Final Report (Vol. V), nearly half of which is already in type, to take up the systematic geology of the state, and many of the details, upon which are based the extensive changes of classification and the new conclusions regarding the problems of archean geology, are reserved for publication in this volume. It seems better, therefore, to reserve any extended criticism of the proposed changes until the full facts upon which they are based are published.

M. L. FULLER.

The Ore Deposits of the United States and Canada. By JAMES F. KEMP, New York, 1900, 3d edition, rewritten and enlarged. xxiv + 481 pp. 163 illustrations.

It is with pleasure that geologists will welcome the new edition of Professor Kemp's work on ore deposits. It is to be noticed that the revision has been so complete and the additions so numerous as to bring the matter up to the date of publication and make it one of the most valuable works of its kind in this country.

Professor Kemp has undertaken a difficult task in endeavoring to embody in a single volume a serviceable text-book and a work of reference. That he has succeeded is shown in the first instance by its increased use in the colleges and in the second by a perusal of its pages.

The general plan of the work remains about the same as in the former editions. The matter is divided into two parts, the first of which treats of the general features of ore deposits, the underlying geological principles, the minerals important as ores, the gangue minerals, and their sources, the structural features of veins, the filling of veins, and the classification of ore deposits. This part of the work would have additional value, especially to the prospector and engineer, if it were illustrated a little more fully by diagrams. It is true the number of illustrations has been increased from 94 to 163, but there is